Kuestion

Network Theory

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Manual for Kuestion

Why Kuestion?

It's very overwhelming for a student to even think about finishing 100-200 questions per chapter when the clock is ticking at the last moment. This is the reason why Kuestion serves the purpose of being the bare minimum set of questions to be solved from each chapter during revision.

What is Kuestion?

A set of 40 questions or less for each chapter covering almost every type which has been previously asked in GATE. Along with the Solved examples to refer from, a student can try similar unsolved questions to improve his/her problem solving skills.

When do I start using Kuestion?

It is recommended to use Kuestion as soon as you feel confident in any particular chapter. Although it will really help a student if he/she will start making use of Kuestion in the last 2 months before GATE Exam (November end onwards).

How do I use Kuestion?

Kuestion should be used as a tool to improve your speed and accuracy chapter wise. It should be treated as a supplement to our K-Notes and should be attempted once you are comfortable with the understanding and basic problem solving ability of the chapter. You should refer K-Notes Theory before solving any "Type" problems from Kuestion.

Type 1: Network Elements

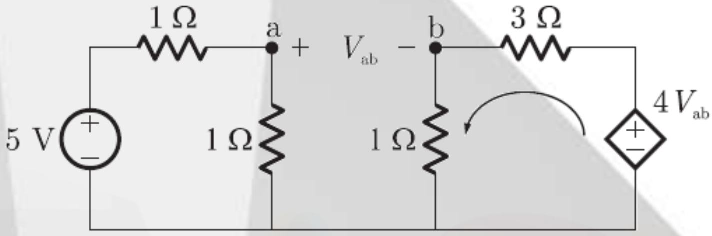
For Concept, refer to Network theory K-Notes, Network Elements

Point to Remember:

While calculating any current or voltage please check the required direction or polarity respectively as the magnitude of your answer may be correct but sign may be opposite.

Sample Problem 1:

In the circuit shown in the figure, the value of the current i will be given by



(A) 0.31 A

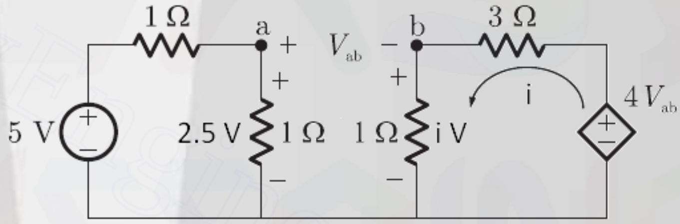
(B) 1.25 A

(C) 1.75 A

(D) 2.5 A

Solution: (B) is correct option

The relevant circuit is



$V_{ab} = 2.5 - i$

Apply KVL in second loop

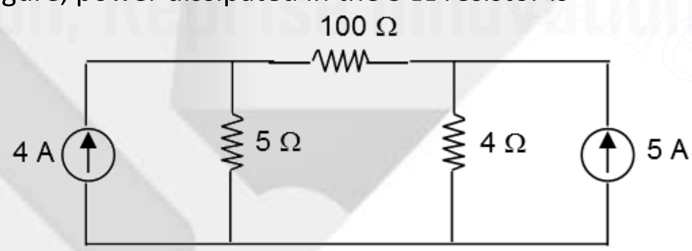
$4V_{ab} = 4i \Rightarrow V_{ab} = i$

$\therefore 2i = 2.5$

$i = 1.25\ A$

Unsolved Problems:

Q.1 In the circuit shown in the given figure, power dissipated in the 5 Ω resistor is



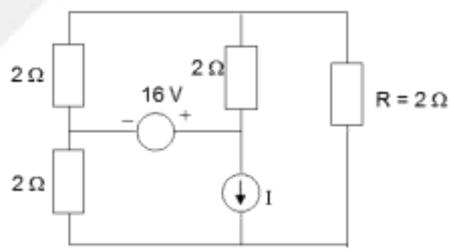
(A) Zero

(B) 80W

(C) 125 W

(D) 405 W

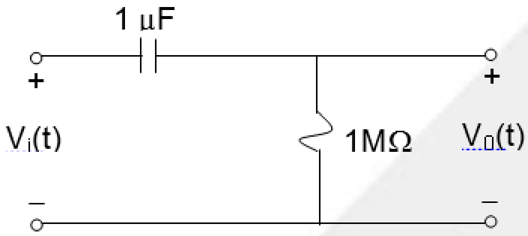
Q.2 In the circuit shown below, if the current through the resistor R is zero, what is the value of I?

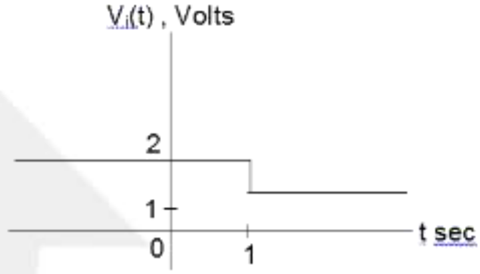


(A) 1 A (B) 2 A

(C) 3 A (D) 4 A

Q.3 In the circuit shown in the following figure, the input voltage $V_i(t)$ is constant at 2V for $-\infty \le t < 1$ sec and then it changes to 1V. The output voltage, $V_0(t)$, 2 sec after the change will be





(A) $-e^{-2}$ V (B) $-1 + e^{-2}$ V (C) e^{-2} V (D) $1 - e^{-2}$ V

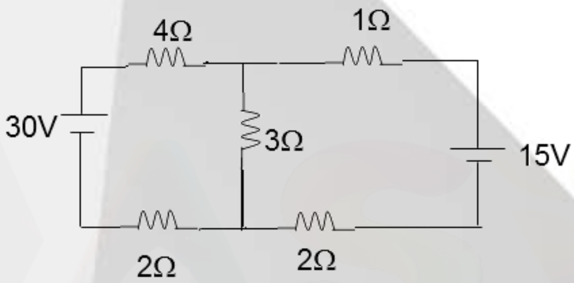
Q.4 The total electrical power consumed by the circuit is

(A) 15W

(B) 75W

(C) 105W

(D) 90W



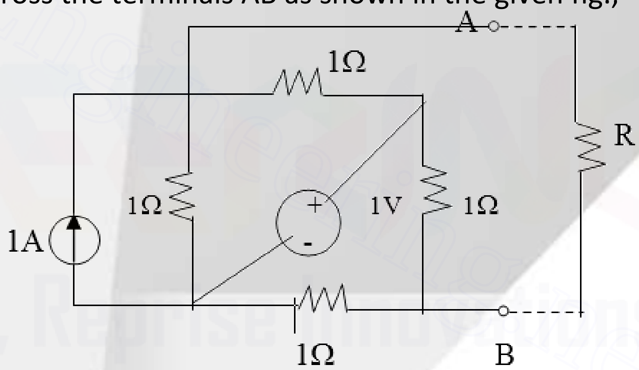
Q.5 If a resistance 'R' of 1Ω is connected across the terminals AB as shown in the given fig., then the current flowing through R will be

(A) 1 A

(B) 0.5 A

(C) 0.25 A

(D) 0.125 A



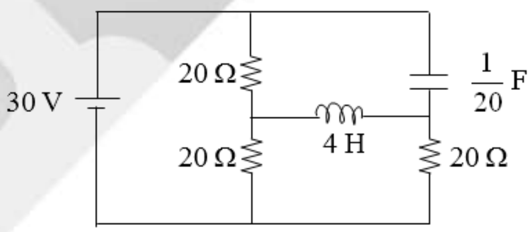
Q.6 In the circuit shown in Fig., the total energy stored in both capacitor and inductor is

(A) 10 J

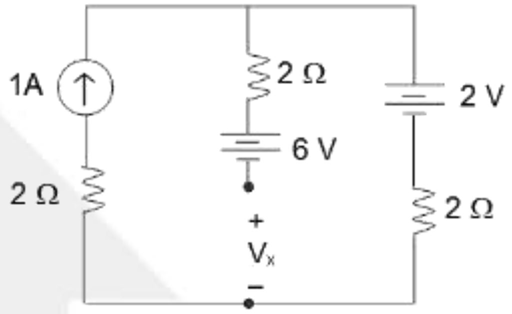
(B) 11 J

(C) 12 J

(D) None



Q.7 Consider the network shown in figure. The current source shown in figure.



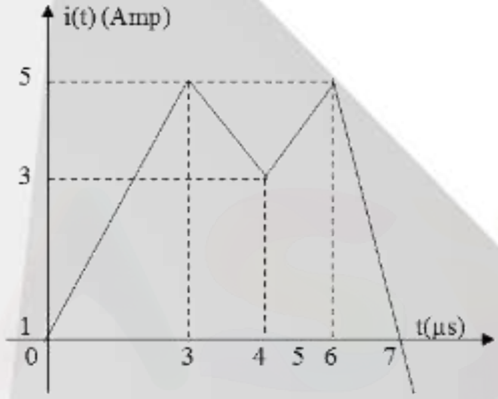
(A) Absorbs 6W

(B) Delivers 6W

(C) Absorbs 12W

(D) Delivers 12W

Q.8 A current i(t) as shown in the fig. is passed through a capacitor. The charge (in micro – coulomb) acquired by the capacitor after 5 μs is



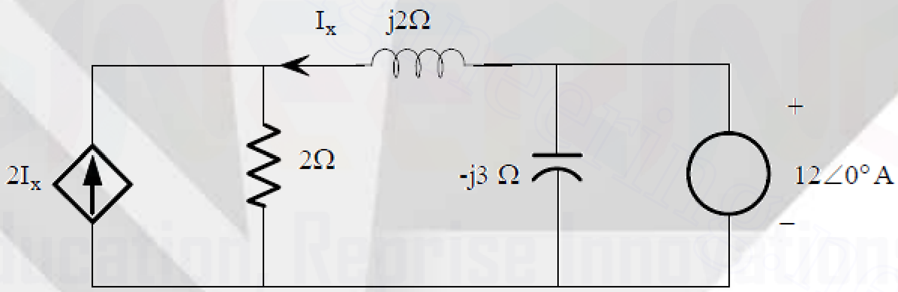
(A) 7.5

(B) 13.5

(C) 14.5

(D) 15

Q.9 Find the average power absorbed by the 2-Ω resistor in the circuit shown below



(A) 18.59 W

(B) 13.56 W

(C) 32.49 W

(D) 25.15 W

Type 2: Graph Theory

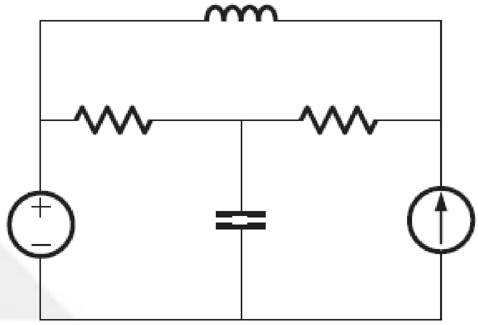
For Concept, refer to Network Theory K-Notes, Graph Theory

Point to Remember:

This topic is not much relevant for GATE so you just need to remember basic concepts like number of trees, number of branches etc.

Sample Problem 2:

The number of chords in the graph of the given circuit will be



(A) 3

(B) 4

(C) 5

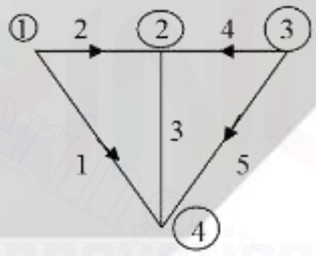
(D) 6

Solution: (A) is correct option

No. of chords is given as
l = b − n + 1
b = no. of branches
n = no. of nodes
l = no. of chords
b = 6, n = 4
l = 6 − 4 + 1= 3

Unsolved Problems:

Q.1 Which one of the following represents the total number of trees in the graph given in the fig.



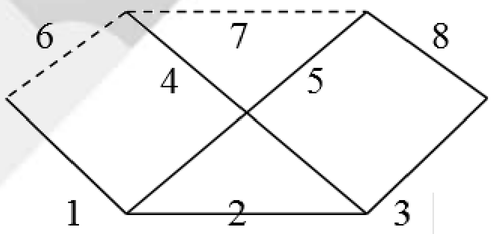
(A) 4

(B) 6

(C) 5

(D) 8

Q.2 In the graph and the tree shown in the given fig., the fundamental cut-set for the branch 2 is



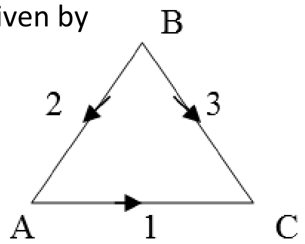
(A) 2,1,5

(B) 2,6,7,8

(C) 2,1,3,4,5

(D) 2,3,4

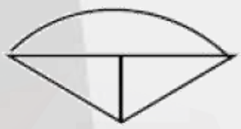
Q.3 For the graph shown in the given fig. the incidence matrix A is given by

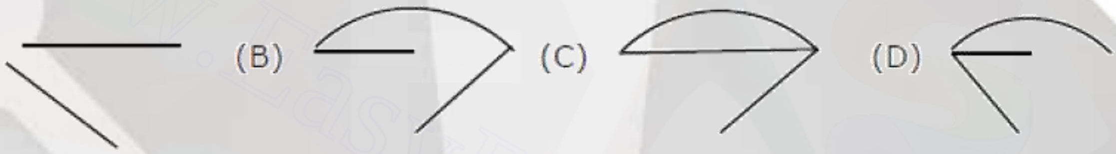


(A) $\begin{bmatrix} -1 & -1 & 0 \\ 0 & 1 & 1 \\ -1 & 0 & -1 \end{bmatrix}$ (B) $\begin{bmatrix} 1 & 0 & -1 \\ 1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$

(C) $\begin{bmatrix} -1 & -1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & -1 \end{bmatrix}$ (D) $\begin{bmatrix} 1 & 0 & 1 \\ -1 & 1 & 0 \\ 0 & 1 & 1 \end{bmatrix}$

Q.4 For the graph shown below which of the following is not a tree





Type 3: Network Theorem

For Concept, refer to Network theory K-Notes, Circuit Theorems

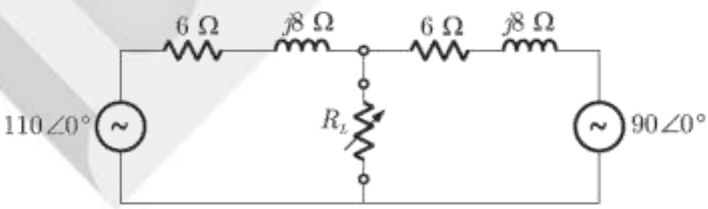
Point to Remember:

For AC circuits having more than one source with different frequencies we need to use Super position Theorem to find the desired parameters.

While applying maximum power transfer theorem please do take care the boundary case that maximum power can be in case of R_L = 0 or infinity.

Sample Problem 3:

Two ac sources feed a common variable resistive load as shown in figure. Under the maximum power transfer condition, the power absorbed by the load resistance R_L is?



(A) 2200 W

(B) 1250 W

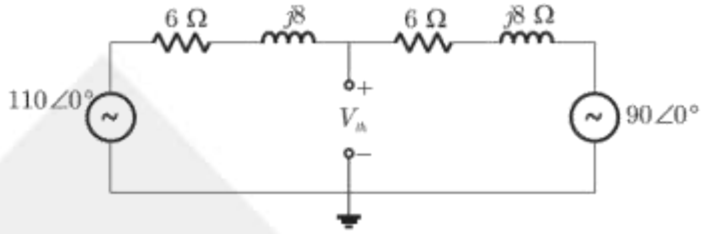
(C) 1000 W

(D) 625 W

Solution: (D) is correct option

First obtain equivalent Thevenin circuit across load R_L

Thevenin voltage

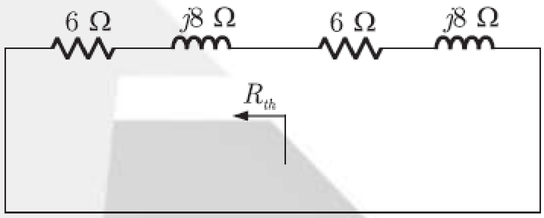


$$\frac{V_{th}-110\angle 0^0}{6+j8}+\frac{V_{th}-90\angle 0^0}{6+j8}=0$$

$$2V_{th}-200\angle 0^0=0$$

$$V_{th}=100\angle 0^0 V$$

Thevenin impedance



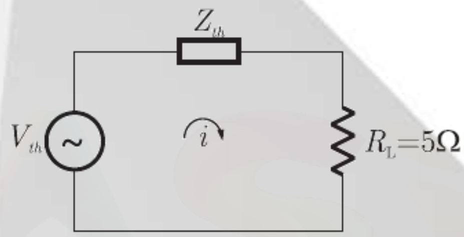
$$Z_{th}=(6+j8)\Omega \,||\, (6+j8)\Omega$$

$$=(3+j4)\Omega$$

For maximum power transfer

$$R_L=|Z_{th}|=\sqrt{(3^2+4^2)}=5\Omega$$

Power in load

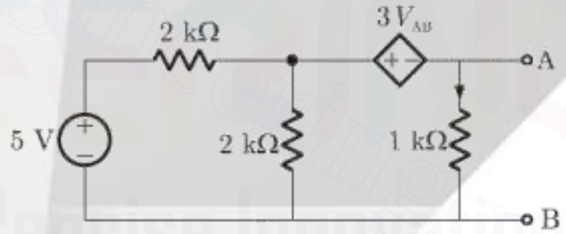


$$P=i_{eff}^2 R_L$$

$$=\left|\frac{100}{3+j4+5}\right|^2\times 5=625\text{ W}$$

Sample Problem 4:

For the circuit given above, the Thevenin's resistance and Thevenin's voltage across the terminals A and B is



(A) 0.5kΩ and 0.25V

(B) 0.2kΩ and 0.5V

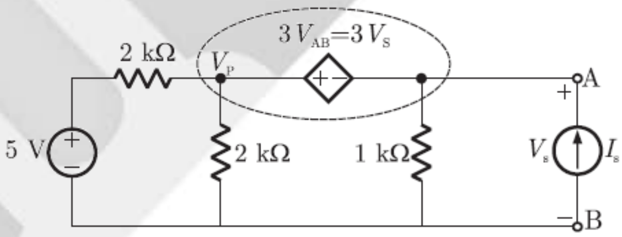
(C) 1.0kΩ and 1.25V

(D) 0.11kΩ and 1V

Solution: (B) is correct option

To obtain equivalent thevenin circuit, put a test source between terminals AB

By applying KCL at super node



$$\frac{V_p-5}{2}+\frac{V_p}{2}+\frac{V_s}{1}=I_s$$

$$V_p-5+V_p+2V_s=2I_s$$

$$V_p+V_s=I_s+2.5$$

And $V_p-V_s=3V_s \Rightarrow V_p=4V_s$

So, $4V_s+V_s=I_s+2.5$

$$V_s=0.2I_s+0.5$$

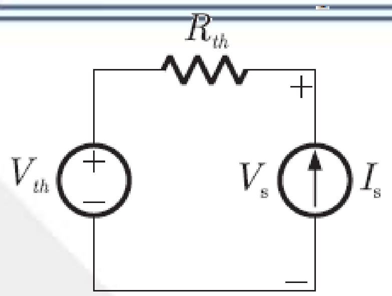
For thevenin equivalent circuit

$V_s = I_s R_{th} + V_{th}$

By comparing

$R_{th} = 0.2k\Omega$

$V_{th} = 0.5V$



Sample Problem 5:

The voltage across the capacitor, as shown in the figure, is expressed as

$v(t) = A_1 \sin(\omega_1 t - \theta_1) + A_2 \sin(\omega_2 t - \theta_2)$

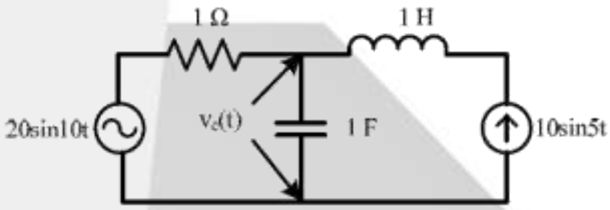
The values of A_1 and A_2 respectively, are

(A) 2.0 and 1.98

(B) 2.0 and 4.20

(C) 2.5 and 3.50

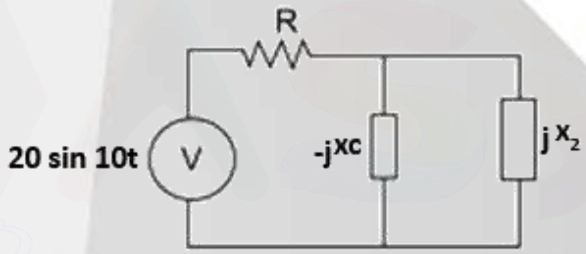
(D) 5.0 and 6.40



Solution: (A) is correct option

Solving using super position theorem

Neglect current source



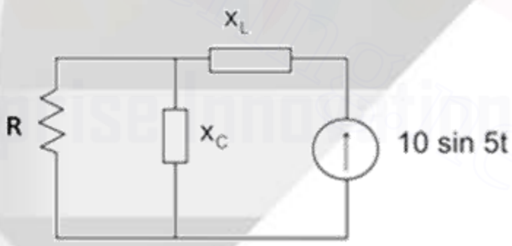
$$X_C = \frac{1}{10 \times 1} = 0.1 \;;\; X_L = \omega L = 10 \times 1 = 10$$

$$V_C = 20 \times \left[\frac{(-j X_C) \,||\, j(X_L)}{R + [(-j X_C) \,||\, (j X_L)]} \right] \;;\; -j\, X_C \,||\, j\, X_L = \frac{(-0.1j) \times 10j}{10j - 0.1j} == -0.1j$$

$$= 20 \times \frac{(-0.1j)}{(10 - 0.1j)} = 2\angle -89.42^\circ$$

$$A_1 = 2 \;;\; \theta_1 = 89.42$$

Neglect voltage source



$$X_C = \frac{1}{5 \times 1} = 0.20, \quad X_L = 5 \times 1 = 5\Omega$$

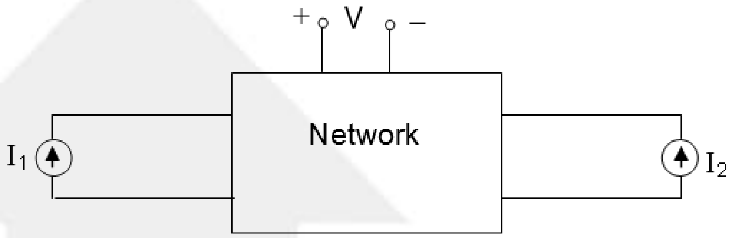
$$I_C = \frac{I_S + R}{R + (-j X_C)} = \frac{10 \times 1}{(1 - 0.2j)} = 9.805 \angle 11.8^\circ$$

$$V_C = I_C(-jX_C) = 1.98 \angle -78.69^\circ$$

$$A_2 = 1.98\,,\; D_2 = 78.69^\circ$$

Unsolved Problems:

Q.1 The linear network as shown above has only resistors, I_1 = 8 Amps and I_2 = 12 Amps, V is found to be 80 V. V_1 = 0 when I_1 = - 8 A and I_2 = 4 A. Then the value of V when $I_1 = I_2$ = 10 A is.



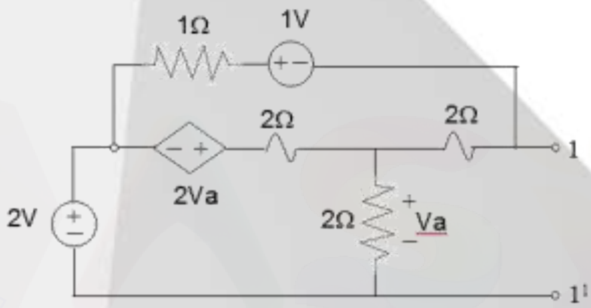
(A) 25 V

(B) 50 V

(C) 75 V

(D) 100 V

Q.2 The Norton's equivalent at the terminals 1 – 1[1] of the network shown in fig is



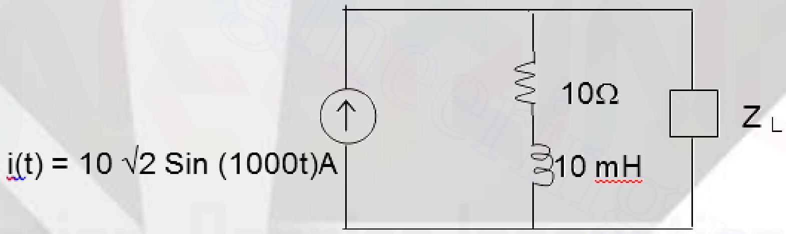
(A) 2A,2Ω

(B) 4A,4Ω

(C) 4A,2Ω

(D) 2A,4Ω

Q.3 In the circuit shown below the maximum power that can be transferred to the load Z_L is



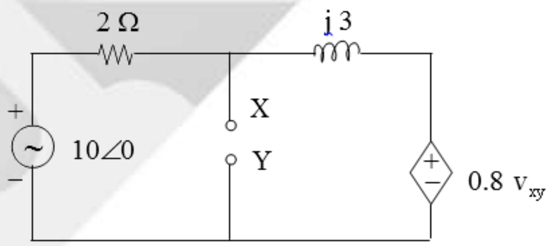
(A) 250W

(B) 500W

(C) 1000W

(D) 2000W

Q.4 What impedance should be connected between X and Y so that it absorbs maximum power?



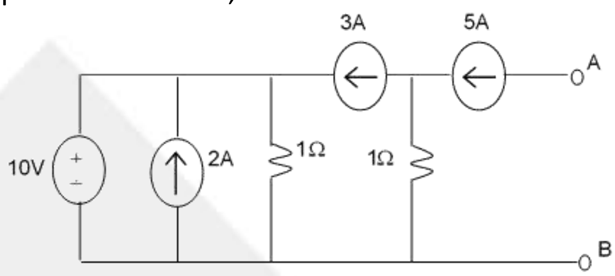
(A) $2\angle 7.6\ \Omega$

(B) $2\angle -7.6\ \Omega$

(C) $0.5\angle 7.6\ \Omega$

(D) None

Q.5 In the circuit shown, the Thevenin's equivalent across A, B is



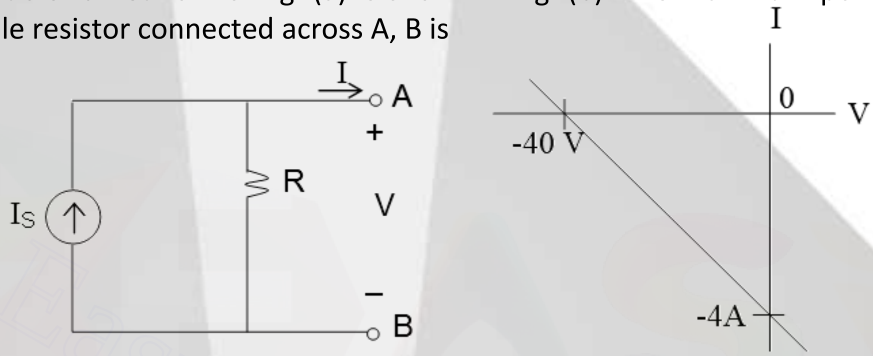
(A) 2V, 1Ω

(B) 5V, 1Ω

(C) 2V, 0.5Ω

(D) Not possible

Q.6 The V-I characteristic of a network of fig. (a) is shown in fig. (b). The maximum power dissipated in the variable resistor connected across A, B is



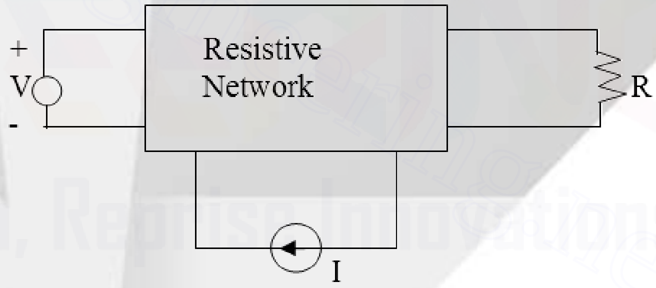
(A) 20 W

(B) 40 W

(C) 60 W

(D) 80 W

Q.7 A dc circuit shown in fig. has a voltage source V, a current source I and several resistors. A particular resistor R dissipates a power of 4 Watts when V alone is active. The same resistor R dissipates a power of 9 Watts when I alone is active. The power dissipated by R when both sources are active will be



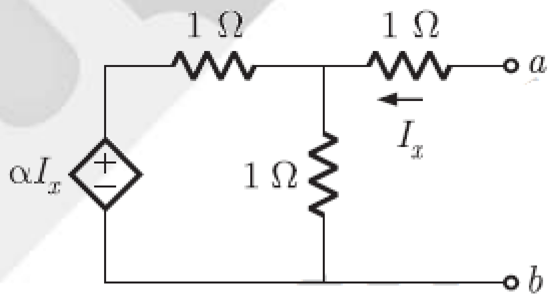
(A) 1 W

(B) 5 W

(C) 13 W

(D) 25 W

Q.8 In the following circuit equivalent Thevenin resistance between nodes a and b is R_{Th} = 3 Ω. The value of a is______



(A) 2

(B) 3

(C) 4

(D) 5

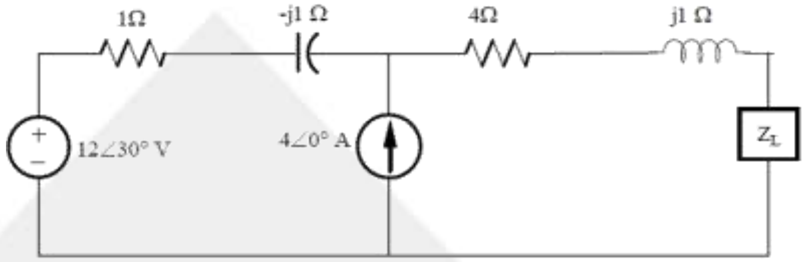
Q.9 Determine the value of the maximum average power absorbed by the load Z_L in the network shown below

(A) 0.52 W

(B) 0.13 W

(C) 0.42 W

(D) 0.23 W



Type 4: Transient Response

For Concept, refer to Network theory K-Notes, Transient Analysis

Point to Remember:

These type of problems can also be solved using Laplace Transform and you need to decide which method to use based on the problem.

Sample Problem 6:

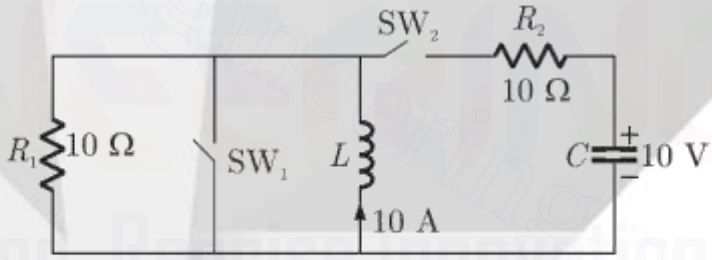
In the circuit shown in figure. Switch SW_1 is initially closed and SW_2 is open. The inductor L carries a current of 10 A and the capacitor charged to 10 V with polarities as indicated. SW_2 is closed at t = 0 and SW_1 is opened at t = 0. The current through C and the voltage across L at ($t = 0^+$) is

(A) 55 A, 4.5 V

(B) 5.5 A, 45 V

(C) 45 A, 5.5 A

(D) 4.5 A, 55 V



Solution: (D) is correct option

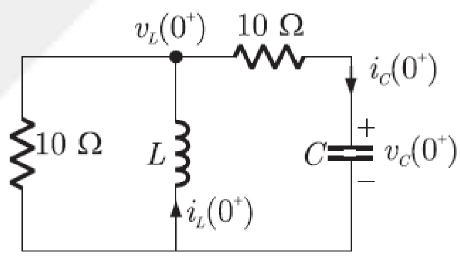
At $t = 0^+$, when switch positions are changed inductor current and capacitor voltage does not change simultaneously

So at $t = 0^+$

$V_c(0^+) = V_c(0^-) = 10V$

$i_L(0^+) = i_L(0^-) = 10A$

The equivalent circuit is



by applying KCL

$$\frac{V_L(0^+)}{10} + \frac{V_L(0^+) - V_c(0^+)}{10} = i_L(0^+) = 10A$$

$$2V_L(0^+) - 10 = 100$$

Voltage across inductor at $t = 0^+$

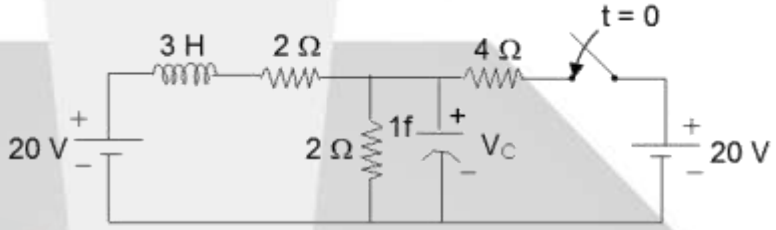
$$V_L(0^+) = \frac{100+10}{2} = 55V$$

So, current in capacitor at $t = 0^+$

$$i_c(0^+) = \frac{V_L(0^+) - V_c(0^+)}{10} = \frac{55-10}{10} = 4.5A$$

Unsolved Problems:

Q.1 The circuit shown below is in steady state with switch open. The switch is closed at $t = 0$ $V_C(\infty)$ is



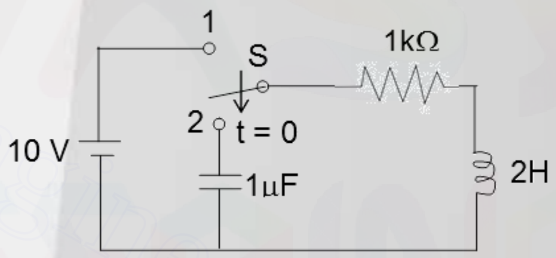
(A) 5 V

(B) 10 V

(C) 20 V

(D) 12 V

Q.2 The switch is in position (1) for a long time and it is moved to position (2) at t=0, find $\frac{d^2i(t)}{dt^2}$ at $t=0^+$



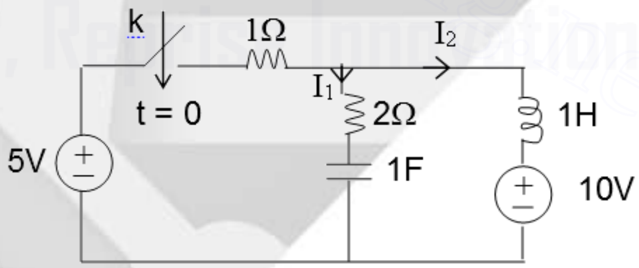
(A) 2500 A/s^2

(B) - 2500 A/s

(C) 5000 A/s^2

(D) 5000 A/s^2

Q.3 In the circuit shown below the steady state is reached with the switch K open. The Switch is closed at time t = 0. $\frac{di_2(t)}{dt}$ at $t=0^+$ is



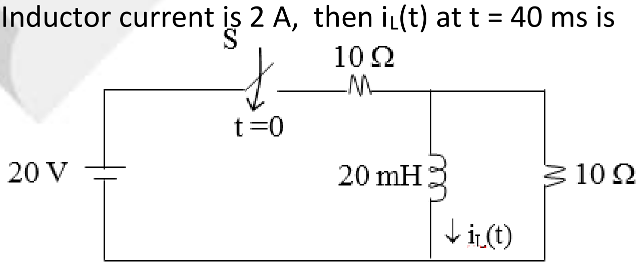
(A) - 5 A/S

(B) - 10/3 A/S

(C) 10/3 A/S

(D) 5 A/S

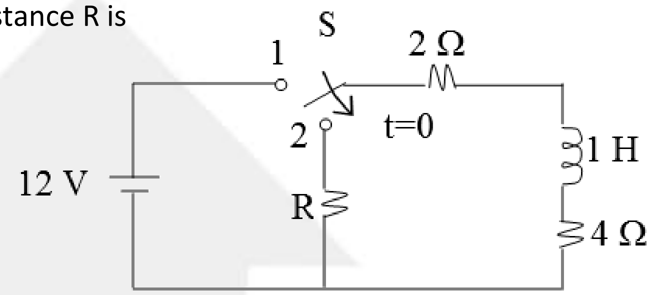
Q.4 For the circuit shown in fig, if the initial Inductor current is 2 A, then $i_L(t)$ at t = 40 ms is



(A) 0.5 A (B) 1 A

(C) 2 A (D) 3 A

Q.5 A coil of inductance 1H and resistance 4Ω is connected as shown in fig. The switch 'S' is in position 1 for a long time and it is moved to position 2 at t = 0. If, at t = 0^+, the voltage across the coil is 12 V, the value of resistance R is



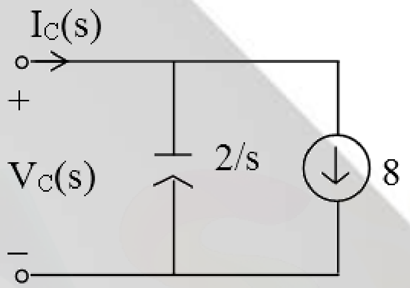
(A) 0Ω

(B) 2 Ω

(C) 4 Ω

(D) 6 Ω

Q.6 The equivalent circuit in the Laplace domain is shown in figure. The Initial voltage across the capacitor is



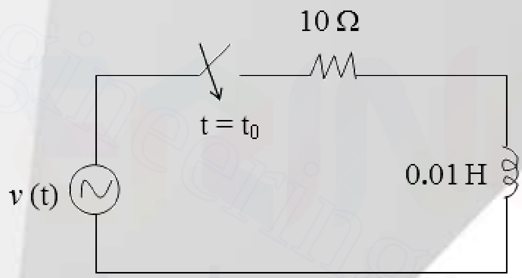
(A) 8V

(B) – 4V

(C) 16V

(D) – 16V

Q.7 Consider the circuit shown in fig., Let the frequency of the source is 50 Hz and the switch is closed at t = t_0. If v(t) = 10 cos (ωt + 10^0) , the value of t_0 which results in a transient free response is



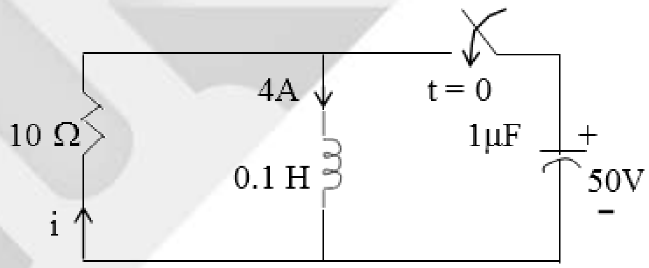
(A) 0 ms

(B) 4.635 ms

(C) 9.27 ms

(D) 8.23 ms

Q.8 For the circuit shown in fig., the switch is opened for a long time and it is closed at t = 0. The value of i and $\frac{dV_C(t)}{dt}$ at t=0^+ is



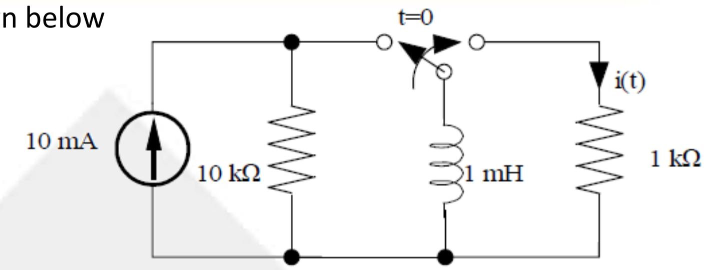
(A) 5 A and –500 A/S

(B) –5 A and –500 A/S

(C) –5 A and 500 A/S

(D) 5 A and 500 A/S

Q.9 find i(t) for t>0 in the circuit shown below



(A) $-10e^{-10^7 t}$ mA

(B) $-10e^{-10^8 t}$ mA

(C) $-5e^{-10^7 t}$ mA

(D) $-5e^{-10^8 t}$ mA

Type 5: Time constant and equivalent impedance

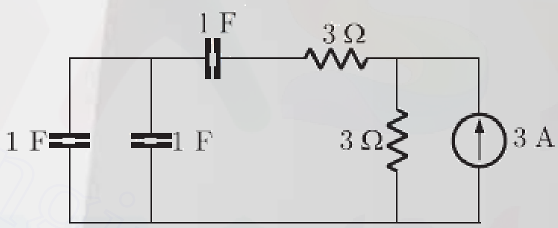
For Concept, refer to Network theory K-Notes, Transient Analysis

Point to Remember:

If we cannot combine the energy storage elements like inductors and capacitors into a single equivalent one then there will exist more than one time-constants in a single circuit.

Sample Problem 7:

The time constant for the given circuit will be



(A) 1/9 s

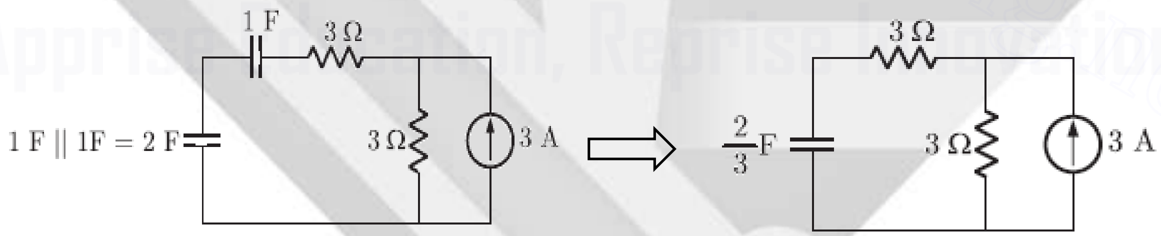
(B) 1/4 s

(C) 4 s

(D) 9 s

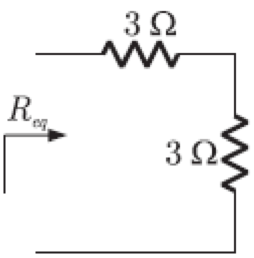
Solution: (C) is correct option

Time constant of the circuit can be calculated by simplifying the circuit as follows



C_{eq}=2/3 F

Equivalent Resistance

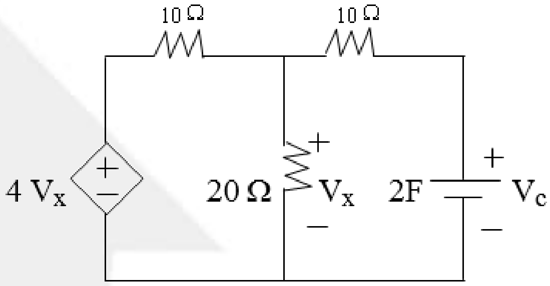


$$R_{eq} = 3 + 3 = 6\Omega$$

$$\text{Time constant} \quad \tau = R_{eq}C_{eq} = 6 \times \frac{2}{3} = 4\,\text{sec}$$

Unsolved Problems:

Q.1 The time constant of the circuit shown in fig., Assume the initial voltage across the capacitor is 6 V.



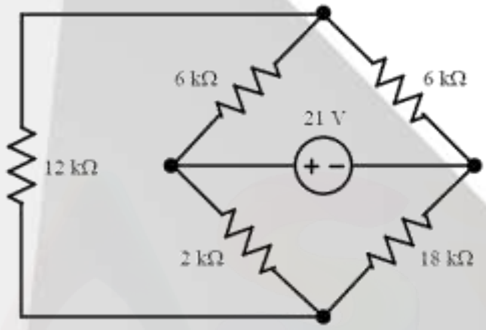
(A) 6 sec

(B) 16.67 sec

(C) 12 sec

(D) 18sec

Q.2 Find the power absorbed by the network shown.



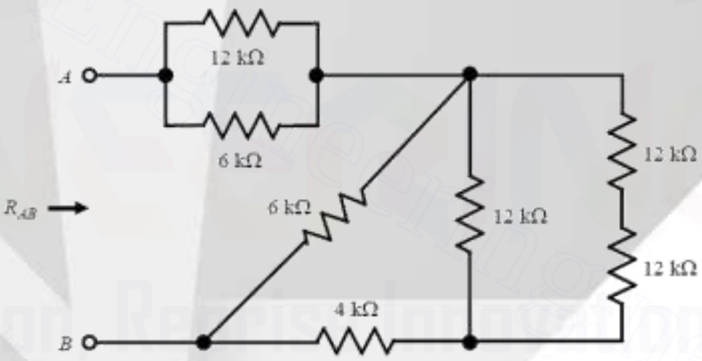
(A) 45 mA

(B) 63 mA

(C) 59 mA

(D) 67 mA

Q.3 Find the equivalent resistance of the circuit shown at the terminals A-B .



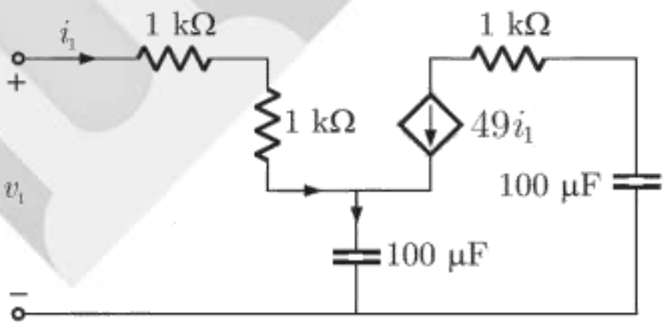
(A) 15 KΩ

(B) 5 KΩ

(C) 10 KΩ

(D) 8 KΩ

Q.4 The equivalent capacitance of the input loop of the circuit shown is



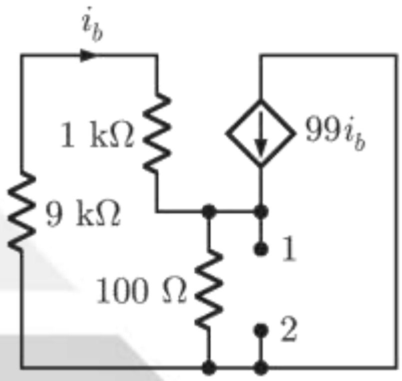
(A) 2 μF

(B) 100 μF

(C) 200 μF

(D) 4 μF

Q.5 The impedance looking into nodes 1 and 2 in the given circuit is



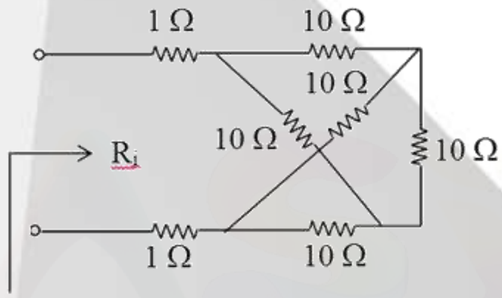
(A) 50 Ω

(B) 100 Ω

(C) 5 kΩ

(D) 10.1 kΩ

Q.6 The value of the input resistance, R_i in the circuit shown in Fig. is



(A) 2Ω

(B) 12 Ω

(C) 22 Ω

(D) None

Type 6: Sinusoidal Steady state analysis

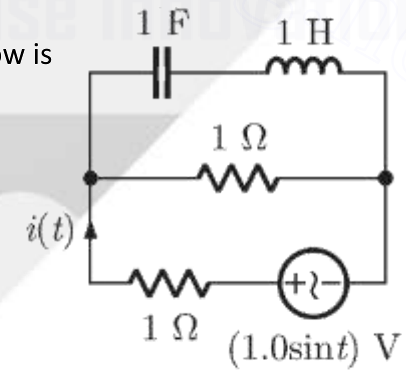
For Concept, refer to Network theory K-Notes, Sinusoidal Steady State Analysis

Point to Remember:

The values given with the sinusoidal terms are always peak values and values given in phasor terms are rms values.

Sample Problem 8:

The r.m.s value of the current i (t) in the circuit shown below is



(A) $\frac{1}{2}$ A

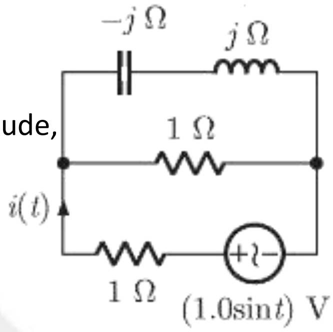
(B) $\frac{1}{\sqrt{2}}$ A

(C) 1 A

(D) $\sqrt{2}$ A

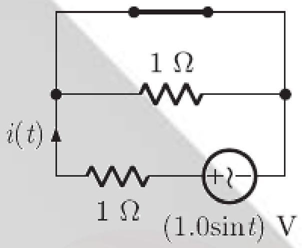
Solution: (B) is correct option

The frequency domains equivalent circuit at $\omega = 1$ rad/ sec.



Since the capacitor and inductive reactance's are equal in magnitude, the net impedance of that branch will become zero.

Equivalent circuit

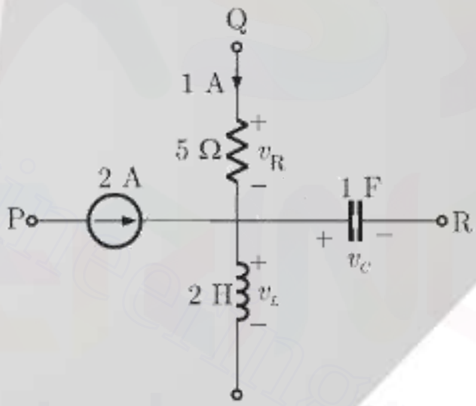


current $i(t) = \dfrac{\sin t}{1\Omega} = (1\sin t)A$

rms value of current $i_{rms} = \dfrac{1}{\sqrt{2}}A$

Sample Problem 9:

A segment of a circuit is shown in figure $V_R = 5V$, $V_C = 4\sin 2t$ .The voltage V_L is given by



(A) 3 – 8 cos2t

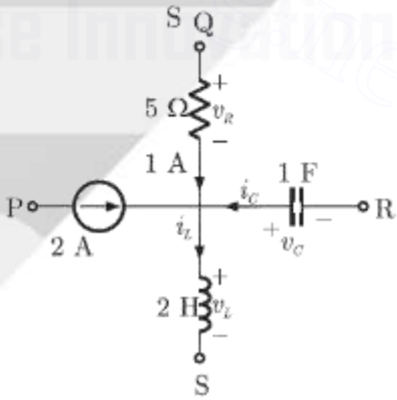
(B) 32 sin2t

(C) 16 sin2t

(D) 16 cos2t

Solution: (B) is correct option

Applying KCL at centre node



$i_c = i_c + 1 + 2$

$i_L = i_c + 3$

$i_c = -C\dfrac{dv_c}{dt}$

$i_c = -1\dfrac{d\left[4\sin 2t\right]}{dt} = -8\cos 2t$

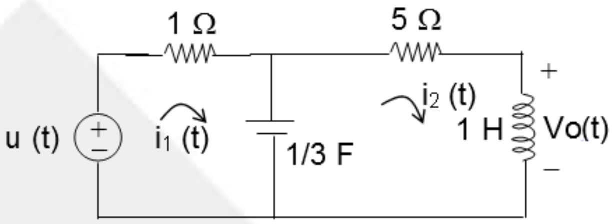
So, $i_L = -8\cos 2t + 3$

Voltage across inductor is

$$v_L = L\frac{di_L}{dt} = 2\times\frac{d\left[3-8\cos 2t\right]}{dt} = 32\cos 2t$$

Unsolved Problems:

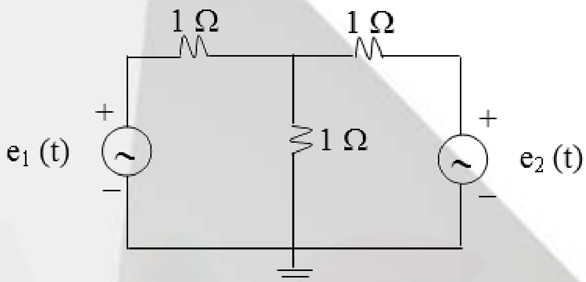
Q.1 Find $V_0(t)$



(A) $\frac{3}{\sqrt{2}}e^{-4t}\sin\sqrt{2}t$ (B) $\frac{3}{2}e^{-4t}\sin 2t$

(C) $\frac{3}{4}e^{-4t}\sin\sqrt{2}t$ (D) $\frac{3}{\sqrt{2}}e^{-4t}\sin 2t$

Q.2 In the circuit shown, $e_1(t) = \sqrt{3}\cos(\omega t + 30^0)$ and $e_2(t) = \sqrt{3}\sin(\omega t + 60^0)$. The voltage across the grounded 1Ω resistor is



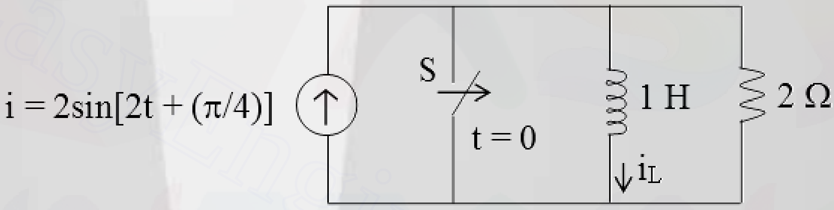
(A) cos(ωt)v

(B) sin(ωt)v

(C) 1v

(D) j 1v

Q.3 In the circuit shown in figure, the steady state current through the inductor $i_L(t)$ is



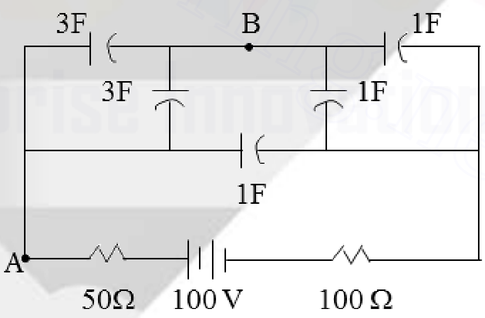
(A) $\sqrt{2}\cos 2t$

(B) $-\sqrt{2}\cos 2t$

(C) $\sqrt{2}\sin 2t$

(D) $-\sqrt{2}\sin 2t$

Q.4 The steady state voltage across the terminals AB of the network shown in fig. is



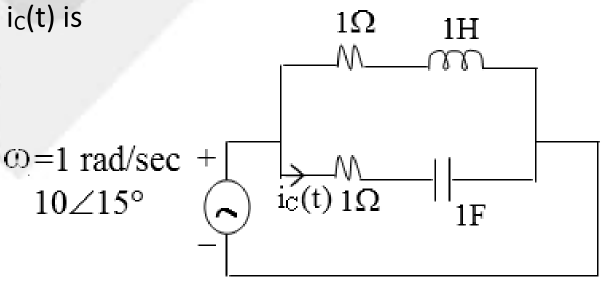
(A) 25V

(B) 50V

(C) 75V

(D) 100V

Q.5 In the circuit shown in figure, the current $i_C(t)$ is



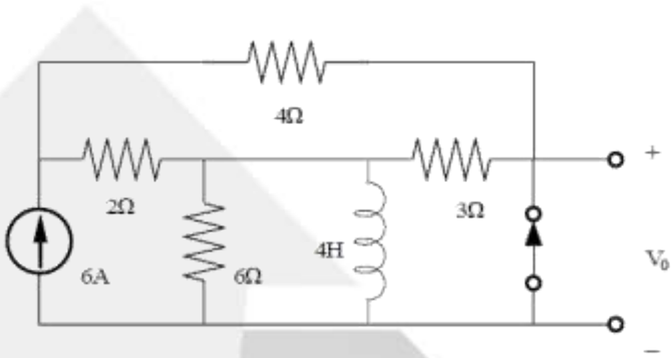
(A) 5cos (t – 30°)A

(B) 5cos (t + 30°)A

(C) $5\sqrt{2}\cos(t - 60°)$A

(D) $5\sqrt{2}\cos(t + 60°)$A

Q.6 find Vo(t),t>0 in the network



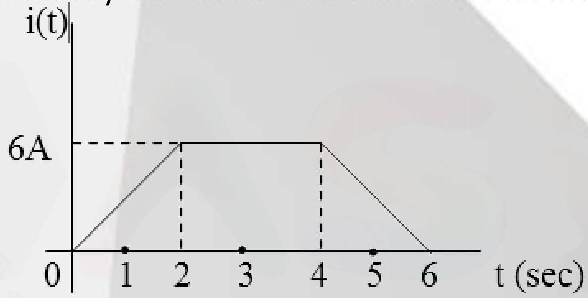
(A) $\left(4+12e^{-\frac{3}{2}}\right)u(t)$ V

(B) $\left(4+6e^{-\frac{3}{2}}\right)u(t)$ V

(C) $\left(2+12e^{-\frac{3}{2}}\right)u(t)$ V

(D) None

Q.7 Fig., shows the waveform of the current passing through an inductor of resistance 1 Ω and inductance 2 H. The energy absorbed and stored by the inductor in the first three seconds is respectively.



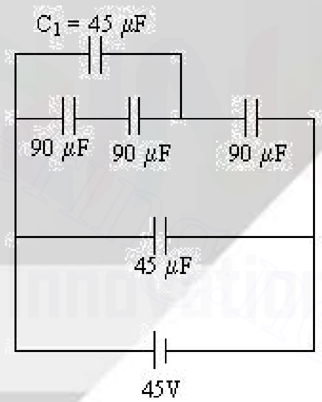
(A) 72 J & 72 J

(B) 96 J & 36 J

(C) 96 J & 72 J

(D) 36 J & 72 J

Q.8 Find charge in the C_1



(A) 2025 μC

(B) 1012.5 μC

(C) 506.25 μC

(D) None

Type 7: Resonance

For Concept, refer to Network theory K-Notes, Resonance

Point to Remember:

Always equate the imaginary part of impedance or admittance to zero for finding the resonance frequency.

Sample Problem 10:

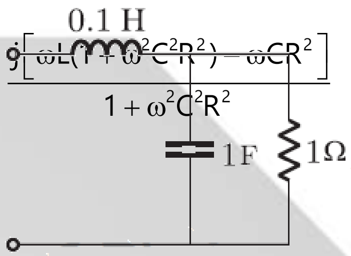
The resonant frequency for the given circuit will be

(A) 1 rad/s (B) 2 rad/s
(C) 3 rad/s (D) 4 rad/s

Solution: (C) is correct option

Impedance of the circuit is

$$Z = j\omega L + \frac{\frac{1}{j\omega C}R}{\frac{1}{j\omega C}+R} = j\omega L + \frac{R}{1+j\omega CR}\times\frac{1-j\omega CR}{1-j\omega CR} = \frac{R}{1+\omega^2C^2R^2} + \frac{j\left[\omega L(1+\omega^2C^2R^2)-\omega CR^2\right]}{1+\omega^2C^2R^2}$$



For resonance Im(Z)=0

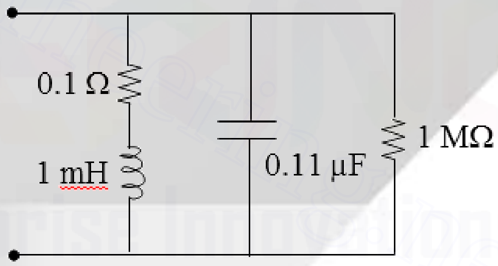
$$\frac{\left[\omega L(1+\omega^2C^2R^2)-\omega CR^2\right]}{1+\omega^2C^2R^2} = 0 \Rightarrow \omega L(1+\omega^2C^2R^2) = \omega CR^2$$

So, $\omega\times 0.1\left[1+\omega^2(1)^2(1)^2\right] = \omega(1)(1)^2$

$1+\omega^2 = 10 \Rightarrow \omega = \sqrt{9} = 3$ rad/sec

Unsolved Problems:

Q.1 For the circuit shown in Fig., the resonant frequency is



(A) 95.3 k rad/sec

(B) 100 k rad/sec

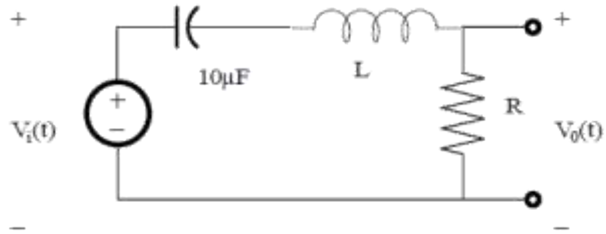
(C) 50 k rad/sec

(D) None

Q.2 A series RLC circuit, excited by a 100V, variable frequency source, has a resistance of 10 Ω and an inductive reactance of 50Ω at 100Hz. If the resonant frequency is 500Hz, then the voltage across the capacitor at resonance is

(A) 100 V (B) 500 V (C) 2500 V (D) 5000 V

Q.3 Given the band-pass shown in fig, find the components L and R necessary to provide a resonant frequency of 1000 r/s and a BW of 100 r/s.



(A) L=500mH, R=10Ω (B) L=100mH, R=20Ω

(C) L=200mH, R=30Ω (D) L=100mH, R=10Ω

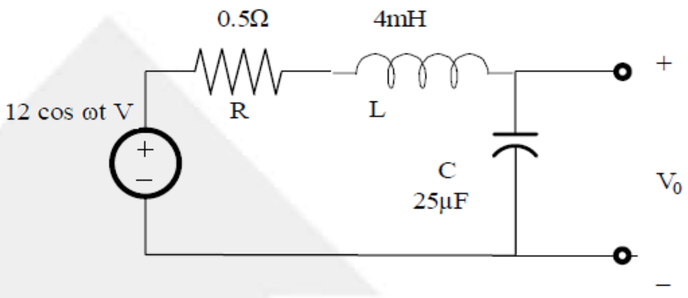
Q.4 Given the network in fig, find Vo(max).

(A) 204.6 V

(B) 305.1 V

(C) 289.1 V

(D) 304.5 V



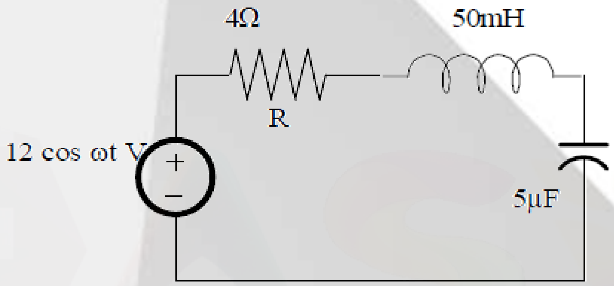
Q.5 A variable frequency voltage source drives the network in fig, determine the average power dissipated by the network at resonance.

(A) 18 W

(B) 20 W

(C) 22 W

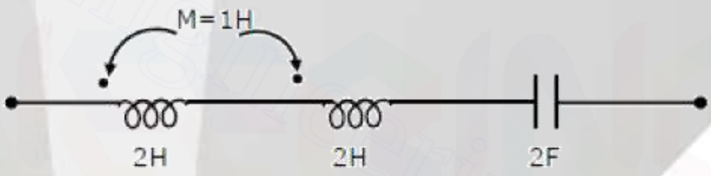
(D) 24 W



Q.6 The resonance frequency of the given circuit is

(A) $\frac{1}{2\pi\sqrt{3}}$Hz (B) $\frac{1}{4\pi\sqrt{3}}$Hz

(C) $\frac{1}{4\pi\sqrt{2}}$Hz (D) $\frac{1}{2\pi\sqrt{2}}$Hz



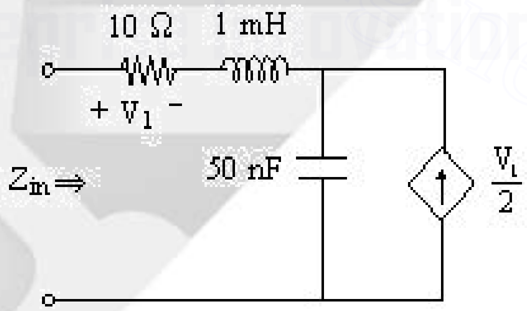
Q.7 For the circuit shown, what is the resonance frequency f_0

(A) 346 KHz

(B) 55 KHz

(C) 196 KHz

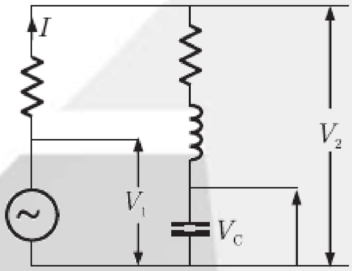
(D) 286 KHz



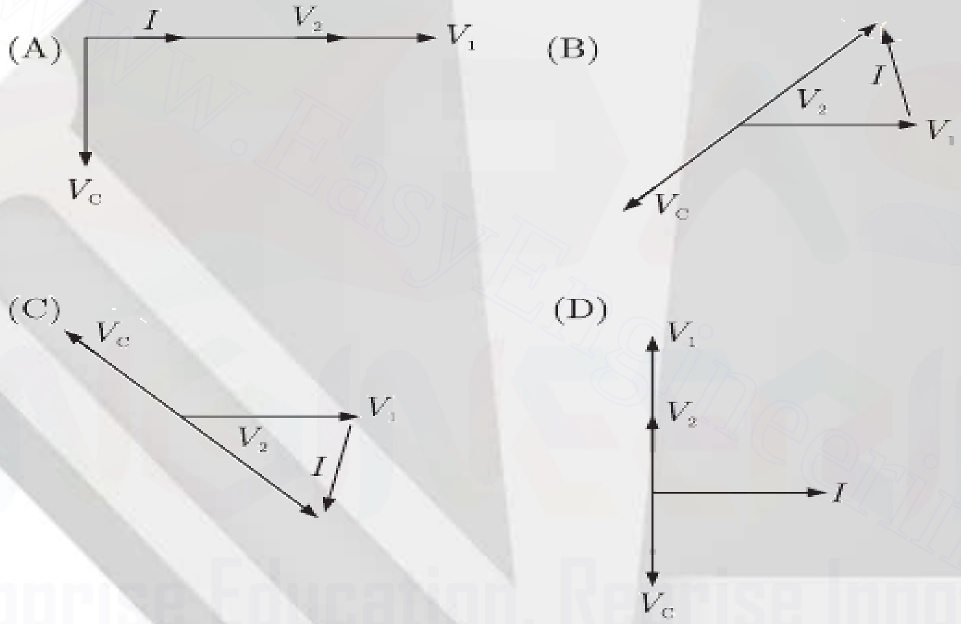
Type 8: Phasor

Sample Problem 11:

The circuit shown in the figure is energized by a sinusoidal voltage source V1 at a frequency which causes resonance with a current of I .



The phasor diagram which is applicable to this circuit is



Solution: (A) is correct option

At resonance reactance of the circuit would be zero and voltage across inductor and capacitor would be equal

$V_L = V_C$

At resonance impedance of the circuit

$Z_R = R_1 + R_2$

$$\text{Current } I_R = \frac{V_1\angle 0^0}{R_1 + R_2}$$

$$\text{Voltage } V_2 = I_2 R_2 + j(V_L - V_C)$$

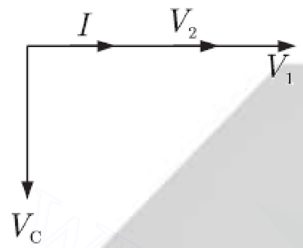
$$V_2 = \frac{V_1\angle 0^0}{R_1 + R_2} R_2$$

Voltage across capacitor

$$V_C = \frac{1}{j\omega C} \times I_R$$

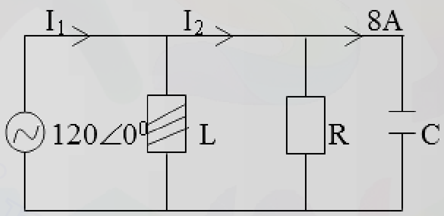
$$= \frac{1}{j\omega C} \times \frac{V_1\angle 0^0}{R_1 + R_2} = \frac{1}{j\omega C} \times \frac{V_1\angle 0^0}{R_1 + R_2} = \frac{V_1\angle -90^0}{\omega C(R_1 + R_2)}$$

So phasor diagram is



Unsolved Problems:

Q.1 In the above circuit, if $|I_1| = |I_2| = 10$ A



(A) I_1 will lead by $\tan^{-1}(8/6)$, I_2 will lag by $\tan^{-1}(8/6)$

(B) I_1 will lead by $\tan^{-1}(6/8)$, I_2 will lag by $\tan^{-1}(6/8)$

(C) I_1 will lag by $\tan^{-1}(8/6)$, I_2 will lead by $\tan^{-1}(8/6)$

(D) I_1 will lag by $\tan^{-1}(6/8)$, I_2 will lead by $\tan^{-1}(6/8)$

Type 9: Two Port Network

For Concept, refer to Network theory K-Notes, Two Port Network

Point to Remember:

Remember the equations for each type of parameters of two port parameters.

Sample Problem 12:

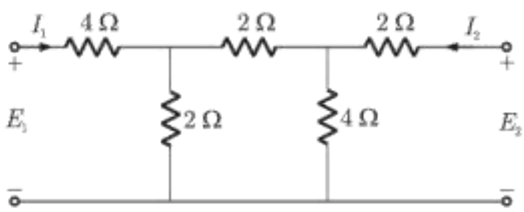
The h-parameters for a two-port network are defined by

$$\begin{bmatrix} E_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$$

For the two-port network shown in figure, the value of h_{12} is given by

(A) 0.125 (B) 0.167

(C) 0.625 (D) 0.25

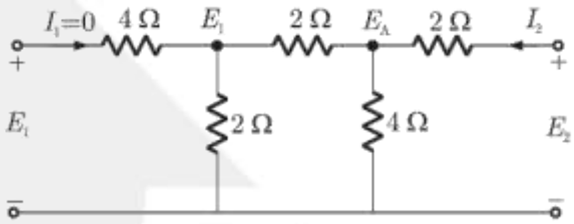


Solution: (D) is correct option

Given that $E_1 = h_{11}I_1 + h_{12}E_2$

$I_2 = h_{21}I_1 + h_{22}E_2$

Parameter h12 is given as $h_{12} = \left.\dfrac{E_1}{E_2}\right|_{I_1=0\text{ (open circuit)}}$



At node A

$$\frac{E_A - E_1}{2} + \frac{E_A - E_2}{2} + \frac{E_A}{4} = 0 \Rightarrow 5E_A = 2E_1 + 2E_2$$

Similarly

$$\frac{E_1 - E_A}{2} + \frac{E_1}{2} = 0 \Rightarrow 2E_1 = E_A$$

By solving above 2 equations

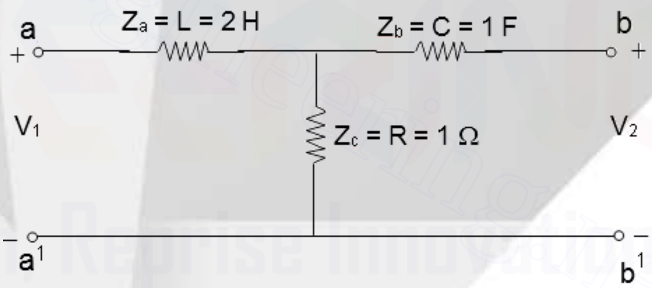
$$5 \times (2E_1) = 2E_1 + 2E_1$$

$$8E_1 = 2E_2$$

$$h_{12} = \frac{E_1}{E_2} = \frac{1}{4}$$

Unsolved Problems:

Q.1 ABCD parameters of the following network is



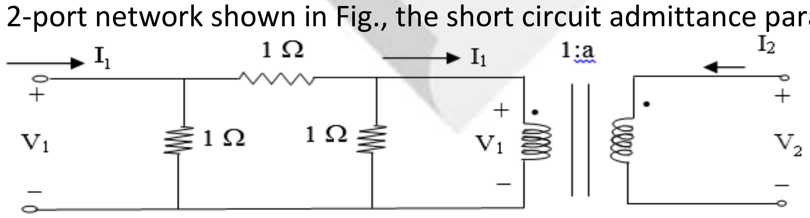
(A) $\begin{bmatrix} 2s+1 & 2s^2+2s+1 \\ 1 & \dfrac{s+1}{s} \end{bmatrix}$

(B) $\begin{bmatrix} 2s+1 & -\dfrac{2s^2+2s+1}{s} \\ 1 & -\dfrac{s+1}{s} \end{bmatrix}$

(C) $\begin{bmatrix} -2s+1 & -\dfrac{2s^2+2s+1}{s} \\ -1 & -\dfrac{s+1}{s} \end{bmatrix}$

(D) None

Q.2 For the 2-port network shown in Fig., the short circuit admittance parameter, y_{11} is

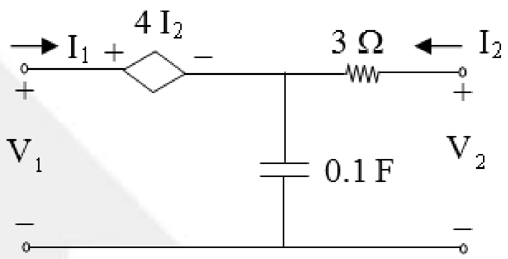


(A) 2 ℧ (B) 0.5 ℧ (C) 2/3 ℧ (D) None

Q.3 For the 2-port network shown in Fig. the open circuit impedance parameter, Z_{12} is

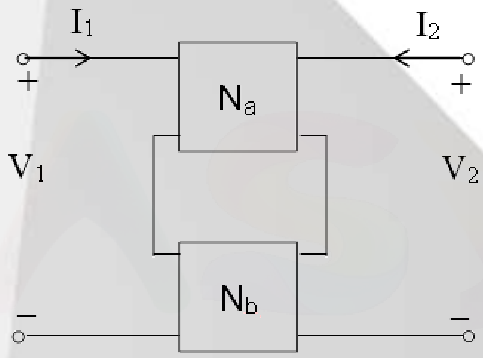
(A) $\frac{s}{4s+10}$ (B) $\frac{4s+10}{s}$

(C) $\frac{10}{s}$ (D) 0



Q.4 Consider the network shown in fig. Let the transmission parameters of the two 2-port Networks are. $T_a = \begin{bmatrix} 2 & 3 \\ 1 & 2 \end{bmatrix}$ and $T_b = \begin{bmatrix} 2 & 3 \\ 1 & 2 \end{bmatrix}$

The impedance parameters of the overall 2-port network is



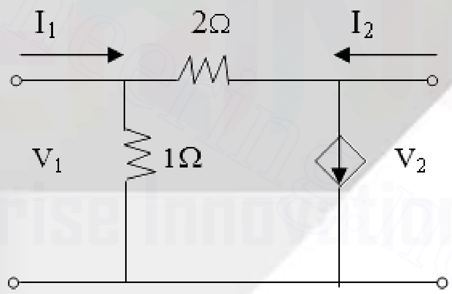
(A) $\begin{bmatrix} 4 & 6 \\ 2 & 4 \end{bmatrix}$ (B) $\begin{bmatrix} 4 & 2 \\ 2 & 4 \end{bmatrix}$

(C) $\begin{bmatrix} 2 & 4 \\ 4 & 2 \end{bmatrix}$ (D) $\begin{bmatrix} 4 & 1 \\ 1 & 3 \end{bmatrix}$

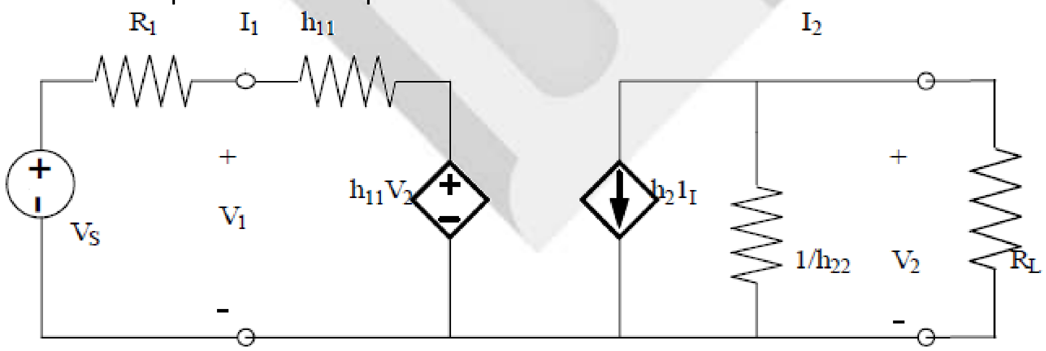
Q.5 The open circuit impedance matrix of the 2 port network shown in fig. is

(A) $\begin{bmatrix} -2 & 1 \\ 8 & 3 \end{bmatrix}$ (B) $\begin{bmatrix} -2 & -8 \\ 1 & 3 \end{bmatrix}$

(C) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ (D) $\begin{bmatrix} 2 & -1 \\ -1 & 3 \end{bmatrix}$



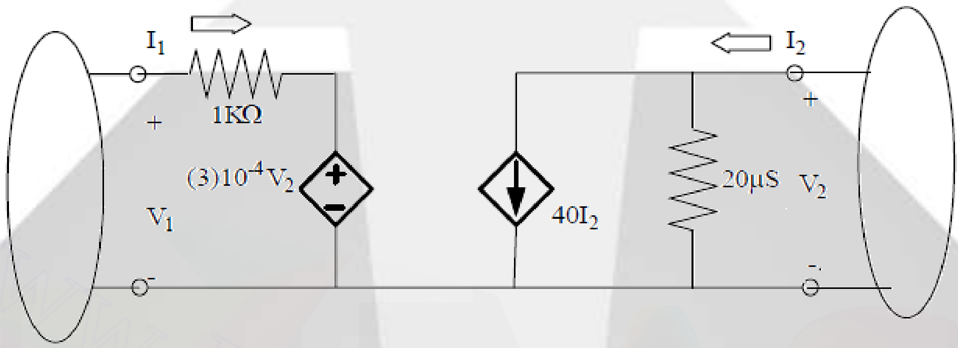
Q.6 Consider the network shown. The two port network is a hybrid model of a basic transistor. Determine the voltage gain of entire network, V_2/V_s, if a source Vs with internal resistance R_1 is applied at the input to the two port and a load RL is connected.



(A) $\dfrac{h_{21}R_L}{h_{12}h_{21}R_L-(1+h_{22}R_L)(R_1+h_{11})}$ (B) $\dfrac{h_{22}R_L}{h_{12}h_{21}R_L-(1+h_{21}R_L)(R_L+h_{11})}$

(C) $\dfrac{h_{21}R_L}{h_{22}h_{21}R_1-(1+h_{21}R_L)(R_1+h_{11})}$ (D) $\dfrac{h_{22}R_1}{h_{22}h_{21}R_1-(1+h_{21}R_L)(R_1+h_{21})}$

Q.7 Find the Z parameters for the two port network shown



(A) $\begin{bmatrix}50K & 15\\ -2\mu & 400\end{bmatrix}$ (B) $\begin{bmatrix}400 & 15\\ 50K & -2\mu\end{bmatrix}$ (C) $\begin{bmatrix}400 & -2\mu\\ 15 & 50K\end{bmatrix}$ (D) $\begin{bmatrix}400 & 15\\ -2\mu & 50K\end{bmatrix}$

Type 10: Three Phase Circuit

For Concept, refer to Network theory K-Notes, Three Phase Circuits.

Point to Remember:

This topic is not asked directly but rather a pre-requisite for many topics such as wattmeter and hence the concepts of lag and lead between line and phase parameters must be understood well.

Sample Problem 13:

Q.1 A 230 V (Phase), 50 Hz, three-phase, 4-wire, system has a phase sequence ABC. A unity power-factor load of 4 kW is connected between phase A and neutral N. It is desired to achieve zero neutral current through the use of a pure inductor and a pure capacitor in the other two phases. The value of inductor and capacitor is

(A) 72.95 mH in phase C and 139.02 μF in Phase B

(B) 72.95 mH in Phase B and 139.02 μF in Phase C

(C) 42.12 mH in Phase C and 240.79 μF in Phase B

(D) 42.12 mH in Phase B and 240.79 μF in Phase C

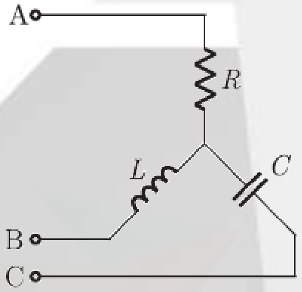
Solution: (B) is correct option

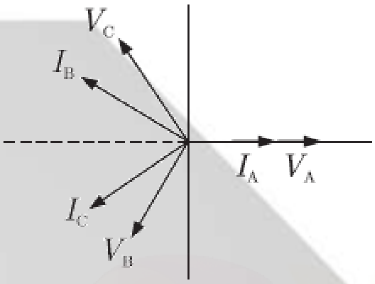
Given that,
230 V, 50 Hz, 3-ϕ, 4-wire system
P = Load = 4 kw at unity Power factor
I_N = 0 through the use of pure inductor and capacitor

Than $\quad L = ?, C = ?$

$\because \quad I_N = 0 = I_A + I_B + I_C$

Network and its Phasor is being as





Here the inductor is in phase B and capacitor is in Phase C.

We know P = VI

So, $\quad I_a = \frac{P}{V} = \frac{4\times10^3}{230} = 17.39$ A

$\vec{I}_A = -(\vec{I}_B + \vec{I}_C)$

$\therefore \vec{I}_A = -(I_B \times \frac{\sqrt{3}}{2} + I_C \times \frac{\sqrt{3}}{2})$

$\therefore \; I_A = \sqrt{3}I_B = \sqrt{3}I_C$

$I_B \cong I_C = \frac{17.39}{\sqrt{3}} = 10$ A

Now $X_c = \frac{V}{I_C} = \frac{230}{10} = 23\Omega$

and $X_c = \frac{1}{2\pi fC} \Rightarrow C = \frac{1}{2\pi fX_c} = \frac{1}{2\pi\times50\times23} = 139.02\mu F$

$X_L = \frac{V}{I_L} = \frac{230}{10} \simeq 23\Omega$

and $X_L = 2\pi fL, \; L \Rightarrow \frac{X_L}{2\pi f} = \frac{23}{2\pi\times100} = 72.95$ mH

So L = 72.95 mH in phase B

C = 139.02 µF in phase C

Unsolved Problems :

Q.1 A positive-sequence balanced three-phase wye-connected source supplies power to a balanced wye connected load. The magnitude of the line voltages is 150 V. If the load impedance per phase is 36 + j12Ω, determine the line currents if $\angle V_{an} = 0^0$

(A) $I_{an} = 2.28\angle -18.43^0$ Arms, $I_{bn} = 2.28\angle -138.43^0$ Arms, $I_{cn} = 2.28\angle -258.43^0$ Arms

(B) $I_{an} = 3.25\angle -28.43^0$ Arms, $I_{bn} = 3.25\angle -148.43^0$ Arms, $I_{cn} = 3.25\angle -268.43^0$ Arms

(C) $I_{an} = 1.39\angle -38.49^0$ Arms, $I_{bn} = 1.39\angle -158.49^0$ Arms, $I_{cn} = 1.39\angle -278.49^0$ Arms

(D) None

Q.2 An abc-phase sequence balanced three-phase source feeds a balanced load. The system is connected wye-wye and $\angle V_{an} = 0^0$. The line impedance is $0.5 + j0.2\ \Omega$, the load impedance is 16+j10 Ω, and the total power absorbed by the load is 1836.54 W. Determine the magnitude of the source voltage V_{an}.

(A) 140 Vrms (B) 120 Vrms (C) 60 Vrms (D) 180 Vrms

Q.3 In a balanced three-phase wye-wye system, the total power loss in the lines is 272.57 W. $V_{an} = 105.28\angle 31.65^0$ Vrms and the power factor of the load is 0.77 lagging. If the line impedance is 2 + j1Ω, determine the load impedance.

(A) 15+j12 Ω (B) 12+j15 Ω (C) 10+j12 Ω (D) 12+j10 Ω

Q.4 In a balanced three-phase wye-wye system, the load impedance is 20 + j12 Ω. The source has an abc phase sequence and $V_{an} = 120\angle 0^0$ V rms. If the load voltage is $V_{AN} = 111.49\angle 0.2^0$, determine the magnitude of the line current if the load is suddenly short circuited.

(A) 48.26 A rms (B) 52.24 A rms (C) 67.42 A rms (D) 49.38 A rms

Type 11: Electric and Magnetic Fields

For Concept, refer to Network theory K-Notes, Electric and Magnetic Fields.

Point to Remember:

This topic is not very complicated and you just need to learn the basic laws of electromagnetism and remember the Maxwell’s Equations well.

Sample Problem 14:

A capacitor consists of two metal plates each 500 $\times$ 500 mm2 and spaced 6 mm apart. The space between the metal plates is filled with a glass plate of 4 mm thickness and a layer of paper of 2 mm thickness. The relative primitivities of the glass and paper are 8 and 2 respectively. Neglecting the fringing effect, the capacitance will be (given that $\varepsilon_0 = 8.854 \times 10^{-12} F/m$)

(A) 983.3 pF (B) 1475 pF (C) 637.7 pF (D) 9956.25 pF

Solution: (B) is correct option

Here two capacitance C_1 and C_2 are connected in series, so equivalent capacitance is

C_1	Glass	$\varepsilon_{r1} = 8;\ d_1 = 4$ mm
C_2	Paper	$\varepsilon_{r2} = 2;\ d_2 = 2$ mm

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$C_1 = \frac{\varepsilon_0 \varepsilon_{r1} A}{d_1} = \frac{8.854 \times 10^{-12} \times 8 \times 500 \times 500 \times 10^{-6}}{4 \times 10^{-3}}$$

$$= 442.5 \times 10^{-11} F$$

$$C_2 = \frac{\varepsilon_0 \varepsilon_{r2} A}{d_2} = \frac{8.854 \times 10^{-12} \times 2 \times 500 \times 500 \times 10^{-6}}{2 \times 10^{-3}}$$

$$= 221.25 \times 10^{-11} F$$

$$C_{eq} = \frac{442.5 \times 10^{-11} \times 221.25 \times 10^{-11}}{442.5 \times 10^{-11} + 221.25 \times 10^{-11}}$$

$$= 147.6 \times 10^{-11} F$$

$$\simeq 1476 \text{ pF}$$

Sample Problem 15:

A dielectric slab with 500 mm $\times$ 500 mm cross-section is 0.4 m long. The slab is subjected to a uniform electric field of $\vec{E} = 6\vec{a}_x + 8\vec{a}_y$ kV/mm. The relative permittivity of the dielectric material is equal to 2. The value of constant ε_0 is 8.85 $\times$ 10^{-12} F/m. The energy stored in the dielectric in Joules is

(A) 8.85 $\times$ 10^{-11} (B) 8.85 $\times$ 10^{-5} (C) 88.5 (D) 885

Solution: (C) is correct option

Energy density stored in a dielectric medium is obtained as $W_E = \frac{1}{2}\varepsilon |E|^2 \ J/m^2$

The electric field inside the dielectric will be same to given field in free space only if the field is tangential to the interface

So, $W_E = \frac{1}{2} 2\varepsilon_0 \left(\sqrt{6^2 + 8^2}\right)^2 \times 10^6 J/mm^2$

Therefore, the total stored energy is

$$W_E = \int_v W_E dv = \varepsilon_0 \times 100 \times 10^6 \ / \ mm^2 \times (500 \times 500) mm^2 \times 0.4$$
$$= \varepsilon_0 \times 100 \times 10^6 \times 0.4 \times 25 \times 10^4$$
$$= 8.854 \times 10^{-12} \times 10^{13} = 88.5J$$

Sample Problem 16:

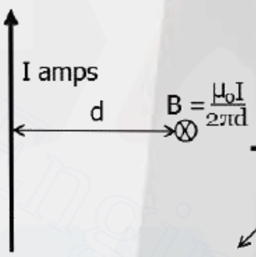
The magnitude of magnetic flux density $(\vec{B})$ at a point having normal distance d meters from an infinitely extended wire carrying current of I A is $\frac{\mu_0 I}{2\pi d}$ (in SI units). An infinitely extended wire is laid along the x-axis and is carrying current of 4 A in the +ve x direction. Another infinitely extended wire is laid along the y-axis and is carrying 2 A current in the +ve y direction. μ_0 is permeability of free space. Assume $\hat{i}, \hat{j}, \hat{k}$ to be unit vectors along x, y and z axes respectively. Assuming right handed coordinate system, magnetic field intensity, $\vec{H}$ at coordinate (2,1,0) will be

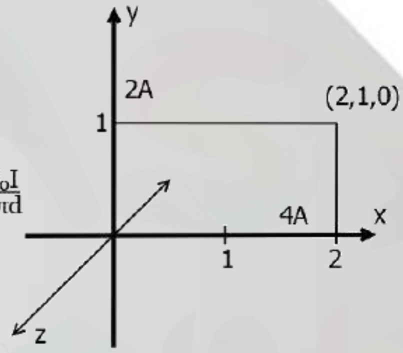
(A) $\frac{3}{2\pi}\hat{k}$ weber/m^2

(B) $\frac{4}{3\pi}\hat{i}$ A/m

(C) $\frac{3}{2\pi}\hat{k}$ A/m

(D) 0 A/m





Solution: (C) is correct option

B = μ_0 H

Magnetic flux density due to current along x – axis = $\frac{\mu_0 \times 4}{2\pi \times 1} = \frac{4\mu_0}{2\pi}\hat{k}$

Density due to current along y-axis = $\frac{\mu_0 \times 2}{2\pi \times 2} = \frac{\mu_0}{2\pi}(-\hat{k})$

$B_{\text{Total}} = \frac{3\mu_0}{2\pi}\hat{k} \Rightarrow \vec{H}_{\text{total}} = \frac{3}{2\pi}\hat{k}\ A/m$

Unsolved Problems:

Q.1 A charge of Q_1 = - 20 μc is located at p(-6, 4, 6) and a charge Q_2 = 50 μc is located at R(5, 8, -2) in a free space. The distances given are in meters. The force exerted on Q_2 by Q_1 is

(A) 22.1 mN (B) 61.4 mN (C) 44.63 mN (D) Zero

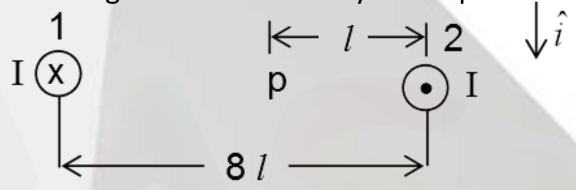
Q.2 A parallel plate capacitor has a plate area of $1m^2$, distance between the plates is 1mm, voltage gradient is 10^5 V/m and the charge density on the plate is 2 $\mu c/m^2$, then the capacitance of a parallel plate capacitor is.

(A) 10 nF (B)30 nF (C) 5 nF (D) 20 nF

Q.3. A total charge of (40/3) nc is uniformly distributed over a circular ring of radius 2m placed in z = 0 plane, with a centre as origin. The electric potential at (0, 0, 5) is

(A) 15.12 V (B) 12.31 V (C) 31.2 V (D) 22.25 V

Q.4 Two infinitely long wires, separated by a distance $8l$, carry currents I in opposite directions, as shown in figure. The expression for the magnetic field intensity at the point P is



(A) $\frac{5I}{8\pi l}\hat{i}$ (B) $\frac{4I}{\pi l}\hat{i}$

(C) $\frac{3I}{\pi l}\hat{i}$ (D)Zero

Q.5 A solid sphere made of insulating material has radius R and has a total charge Q distributed uniformly in its volume. What is the magnitude of the electric field intensity, E, at a distance r (0 < r < R) inside the sphere?

(A) $\frac{1}{4\pi\epsilon_0}.\frac{Qr}{R^3}$ (B) $\frac{3Qr}{4\pi\epsilon_0 R^3}$ (C) $\frac{1}{4\pi\epsilon_0}.\frac{Q}{r^2}$ (D) $\frac{1}{4\pi\epsilon_0}.\frac{QR}{r^3}$

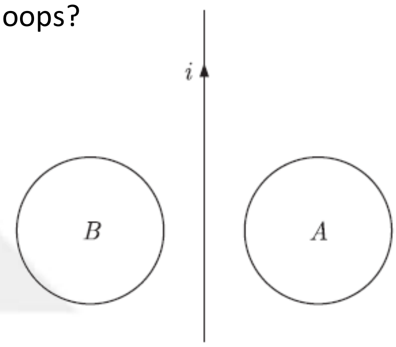
Q.6 Three sheet charges are located at x = 2, with ρ_{s1} = 10 nc/m^2, y = 4, with ρ_{s2} = -5 nc/m^2 and z = -5 with ρ_{s3} = 8 nc/m^2.The $\vec{E}$ at $(3, 5, 0)$ is

(A) $\frac{1}{2\varepsilon_0}\left(10\, a_x - 5\, a_y + 8\, a_z\right)$nN/c (B) $\frac{1}{2\varepsilon_0}\left(-10\, a_x + 5\, a_y + 8\, a_z\right)$nN/c

(C) $\frac{1}{2\varepsilon_0}\left(10\, a_x - 5\, a_y - 8\, a_z\right)$nN/c (D) None of these

Q.7 Magnetic field intensity is **H** = 3**a**x + 7y**a**y + 2x**a**z A/m. What is the current density **J** A/m^2?
(A) -2$\mathbf{a}_y$ (B) -7$\mathbf{a}_z$ (C) 3$\mathbf{a}_x$ (D) 12$\mathbf{a}_y$

Q.8 A straight current carrying conductor and two conducting loops A and B are shown in the figure given below. What are the induced current in the two loops?



(A) Anticlockwise in A and clockwise in B

(B) Clockwise in A and anticlockwise in B

(C) Clockwise both in A and B

(D) Anticlockwise both in A and B

Q.9 Let $\nabla \bullet (f\,\vec{v}) = x^2y + y^2z + z^2x$, where f and v are scalar and vector fields respectively. If $\vec{v} = y\vec{i} + z\vec{j} + x\vec{k}$, then $\vec{v} \bullet \nabla f$ is

(A) 0 (B) $2xy + 2yz + 2zx$ (C) $x + y + z$ (D) $x^2y + y^2z + z^2x$

Answer Key

	1	2	3	4	5	6	7	8	9
Type 1	C	D	A	C	D	B	B	D	C
Type 2	D	C	C	C					
Type 3	D	C	B	B	D	B	A, D	B	C
Type 4	C	B	B	C	C	D	C	C	A
Type 5	C	B	D	A	A	B			
Type 6	A	A	C	A	D	A	B	B	
Type 7	A	C	D	B	A	B	B		
Type 8	C								
Type 9	C	A	B	B	A	A	D		
Type 10	A	B	D	C					
Type 11	C	D	D	B	A	D	A	A	D